



CO₂ Scrubber and Vent Gas Scrubber

The CO₂ Scrubber (C-3201) and the Vent Gas Scrubber (C-3202) together comprise the Vent Gas Scrubbing System. The Vent Gas Scrubbing System is one of the air emission control systems at the facility used to reduce the ethanol plant's environmental footprint. Dry Mill ethanol production facilities generate regulated air emission byproducts. Water soluble volatile organic compounds, primarily in the form of ethanol, are generated throughout the manufacturing process. Vent gas produced from the operating equipment has trace amounts of VOC's, which must be removed prior to discharging it to the environment or collecting it for resale.

The exhaust vents that contain VOCs are piped to the Vent Gas Scrubbing system. Water is used to separate and remove the ethanol and other impurities from the exhaust gas. The purified vent gas (primarily CO₂) is then safely and legally exhausted to the atmosphere, and the ethanol contained in the scrubbing water is recovered and either collected in the Process Condensate Tank or processed in the Evaporator Condensate Receiver.

Safety:

All employees are required to use safe work practices while performing their duties. Safe work practices are described in the plant Safety Manual and in the appropriate Operating Procedures. All Safety Rules and Procedures must be followed at all times. If unsure of any safety related item, the supervisor shall be consulted.

The items listed below are a few safety guidelines that must be observed. The list is not complete and is not intended to preclude or in any way conflict with the policies set forth in the plant Safety Manual. In general:

CO₂ is an asphyxiant. Before entering any vessel connected to the CO₂ Scrubber of the Vent Gas Scrubber, the vessel must be properly isolated and locked out per company policy. The vessel must be properly purged and the atmosphere tested to ensure the proper oxygen level.

Proper personal protection equipment will be worn at all times. This includes safety glasses, proper safety shoes and hard hats where required. Additional PPE may be required based on the work being performed.

No one is allowed to enter a confined space without properly authorized Confined Space and Safe Work Permits.

All equipment guards must be in place before the affected equipment is started and at all times when the equipment is operating.

No equipment will be operated with any safety device, trip or interlock defeated. The location of the nearest safety shower and eyewash station must be noted before working with hazardous chemicals.

Chemical spills must be reported to proper management personnel and cleaned up properly following plant policy and the instructions in the Material Safety Data Sheets (MSDSs).

Vent Gas Scrubbing System Process Description

The CO₂ Scrubber, C-3201, is a packed column that processes exhaust gasses collected from the Fermenters and Beer well. The exhaust gas enters the lower section of the CO₂ Scrubber column and rises to the top of the column. Water spray enters the top of the column and falls by gravity to the bottom. The ethanol and other VOC impurities have a natural affinity to water, and attach themselves to the water molecules as the two mediums come into contact with one another. A 20 foot section of the tower is packed with random polypropylene packing to improve the water/gas contact and enhance the absorption efficiency of the CO₂ Scrubber. The operating pressure of the CO₂ Scrubber is 14.7 psia (0 psig). The temperature at the top of the column is approximately 73 °F (23°C).

Ethanol and soluble impurities entrained in the CO₂ streams which dissolve in the water are sent to the Evaporator Condensate Receiver, VS-4505 for recovery. Valves can also be aligned to send the water to the Process Condensate Tank. The scrubbed CO₂ exhaust gas is vented to the atmosphere. At a later date it may be desirable to recover the scrubbed CO₂ for its commercial value.

The Vent Gas Scrubber, C-3202, is a packed column that processes exhaust gasses collected from the various process vessels in the plant. The exhaust gasses, some aided by a blower, enter the lower section of the Vent Gas Scrubber column and rise toward the top of the column. Water spray into the top of the column contacts the rising gas and absorbs impurities. A 20 Foot section of the tower is packed with random polypropylene packing to improve the water/gas contact and enhance the absorption efficiency of the Vent Gas Scrubber. The operating pressure of the Vent Gas Column is 14.7 psia (0 psig). The temperature at the top of the column is approximately 73°F (23°C).

Small amounts of ethanol entrained in the vent gas streams, as well as trace amounts of soluble impurities, are dissolved in the water. The water from the Vent Gas Scrubber flows by gravity to, and is combined, with the outlet of the CO₂ Scrubber. The combined stream is pumped to the Evaporator Condensate Receiver in the DD&E Area, VS-4504.

EQUIPMENT NAME	EQUIPMENT #	REFERENCE P&ID
Fermenter #1	TK-3104	61081-PI-3103
Fermenter #2	TK-3105	61081-PI-3104
Fermenter #3	TK-3106	61081-PI-3105
Fermenter #4	TK-3107	61081-PI-3106
Beerwell	TK-3108	61081-PI-3107

The exhaust gases from the Fermenters and Beer Well combine into one main header, enter the CO₂ Scrubber at the bottom and travel upwards through the column. Process water from the process water system enters at the top of the column. The water falls through the packing and toward the bottom of the column. As the water contacts the gasses (mostly CO₂) flowing upwards, the ethanol and other solubles are scrubbed out of the gasses. The scrubbed CO₂ is vented outside of the building and to the atmosphere. Additional water from the bottom of the Vent Gas Scrubber, C-3202, is combined with the water from the CO₂ Column in the suction line of the pump.

The Primary Scrubber Pump, PC-3201, transports the ethanol entrained CO₂ Scrubber water to the Evaporator Condensate Receiver, VS-4504. The ethanol is recovered from the water prior to it being sent to the Condensate Preheater.

Temperature transmitter TT-32123 monitors the temperature of the discharging CO₂ exhaust gas at the top of the CO₂ exhaust gas at the top of the CO₂ Scrubber which is indicated by temperature indicator TI-32123. Temperature transmitter TT-32118 monitors the temperature of the process water being fed to the CO₂ Scrubber which is also indicated by temperature indicator TI-32118. A sudden spike in temperature represents possible upset conditions at the CO₂ Scrubber that should be investigated promptly.

Flow transmitter FT-32119 monitors the flow of process water to the CO₂ Scrubber and sends a signal to flow indicating controller FIC-32119. FIC-32119 controls flow valve FV-32119 which regulates the amount of water sent to the CO₂ Scrubber. Flow totalizer FQI-32119 indicates a running total of the amount of water going to the CO₂ Scrubber. A flow alarm high or flow alarm low is indicated if the flow of the water to the CO₂ Scrubber deviates from the setpoint. The initial minimum water flow is estimated to be 30 GPM for the CO₂ Scrubber. Excessive water flow can cause too much back pressure in the CO₂ Scrubber and increase vapor pressure in the distillation area. Water flow to the CO₂ Scrubber should not exceed 60 GPM.

Pressure differential transmitter, PDT-32103, monitors the differential pressure across the packed section of the CO₂ Scrubber, which is indicated by pressure differential indicator PDI-32103. A differential pressure alarm high is annunciated if the differential pressure reaches a predetermined value. It is expected that normal operations will indicate a differential pressure of less than 0.5 pound per square inch differential (psid) at the CO₂ Scrubber.

It is possible for mash to get to the CO₂ Scrubber if a fermenter is allowed to overflow. If this happens, the CO₂ Scrubber packing should be inspected and replaced, if necessary, at the earliest opportunity. Fouled packing results in increased backpressure and reduced CO₂ Scrubber capacity. Indications of fouled packing are excessive differential pressure and/ or increased backpressure in the vessel connected to the Scrubber System.

Level Transmitter LT-32101, monitors the level of water (process water) in the bottom of the CO₂ Scrubber and sends a signal to level indicating controller LIC-32101. LIC-32101 controls level valve LV-32101 to regulate the level in the CO₂ Scrubber. A level alarm high or level alarm low is annunciated if the level of water in the CO₂ Scrubber deviates from set point.

If the access cover of a connected vessel must be opened, the CO2 vent isolation valve for that equipment must be closed. Closing the valve prevents short-circuiting the CO2 (and other hazardous gasses) from other vessels to the open vessel. Short-circuiting can create an unsafe environment and possibly upset operations in other areas by reducing the pressure in the exhaust gas header.

Section 4.2

EQUIPMENT NAME	EQUIPMENT #	REFERENCE P&ID
Slurry Mix Tank	TK-2101	61081-PI-2101
Process Condensate Tank	TK-7601	61081-PI-7601
Centrifuges (4)	CF-5101/2/3/4	61081-PI-5101
Thin Stillage Collection Tank	TK-5101	61081-PI-5101
Yeast Propagation Tank	TK-3102	61081-PI-3101
Yeast Mix Tank	TK-3101	61081-PI-2201
Liquefaction Tank	TK-2201	61081-PI-2201
Thin Stillage Tank	TK-5103	61081-PI-5102
Whole Stillage Tank	TK-5102	61081-PI-5101
Syrup Tank	TK-5104	61081-PI-5102
Evaporator Vacuum Receiver	VS-4505	61081-PI-4502
Beer Column Vent Condenser	E-4102	61081-PI-4101
Reflux Vent Condenser	E-4203	61081-PI-4201
Regeneration Receiver	E-4303	61081-PI-4301

Most of the vent gas from the above-listed process vessels are combined into two main headers. The flow in one header is aided by the Process Vapor Blower, BL-3202. The blower discharge combines with the second header prior to entering the Vent Gas Scrubber and travel upwards through the column. Process water from the process water system enters at the top of the column. The water falls through the packing and toward the bottom of the column. As the water contacts the gas flowing upwards, the ethanol and other soluble are removed from the gas. The scrubbed gas is then vented outside of the building to the atmosphere.

Water from the bottom of the Vent Gas Scrubber is pumped by the Primary Scrubber Pump to the Evaporator Condensate Receiver.

Flow Transmitter, FT-32120, monitors the flow of process water to the Vent Gas Scrubber and sends a signal to flow indicating controller FIC-32120. FIC-32120 controls flow valve FV-32120 and regulates the amount of water sent to the Vent Gas Scrubber. Flow Totalizer FQI-32120 indicates a running total of the amount of water going to the Vent Gas Scrubber. A flow alarm indicates deviation from the set points. The initial minimum water flow is estimated to be 16 GPM for the Vent Gas Scrubber. Too much water to the Scrubber System can cause excessive back pressure in the scrubbers and increase vapor pressure in the distillation area.

Pressure differential transmitter, PDT-32109, monitors the differential pressure across the packed section of the Vent Gas Scrubber Column. The differential pressure is indicated by Pressure Differential Indicator PDI-32109. It is expected that normal operations will indicate a differential pressure of less than 0.5 pound per square inch differential (psid).

If the access cover of a connected vessel must be opened, the CO₂ vent isolation valve for that equipment must be closed. Closing the valve prevents short-circuiting the CO₂ (and other hazardous gasses) from other vessels to the open vessel. Short-circuiting can create an unsafe environment and possibly upset operations in other areas by reducing the pressure in the exhaust gas header(s).

The Vent Gas Scrubbing System MUST be started prior to process vessels connected to either the CO₂ Scrubber or the Vent Gas Scrubber. Refer to the tables in Section 4.2. The Vent Gas Scrubber and the CO₂ Scrubber are an interconnected system sharing level control. One pump services the system. Both Scrubbers must be started at the same time.